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THE WORKS OF TORRICELLI.

Opere di Evangelista Torricelli. Edite da Gino Loria e Giuseppe Vassura. Vol. i. Parte 1. Pp. xxxviii+407. Vol. i. Parte 2. Pp. 482. Vol. ii. Pp. 320. Vol. iii. Pp. 521. (Faenza: G. Montanari, 1919.) Price 60 franchi the 3 vols.

THIS work consists nominally of three volumes, of which the first contains mathematical papers, the second papers on mechanics, and the third the correspondence of Torricelli. In reality there are four volumes. It is to be hoped that this inconvenient way of describing the volumes of a work will soon go out of fashion. This is the first complete edition of the collected writings of Evangelista Torricelli; it is published under the auspices of the municipality of his native town, Faenza, who have in this way raised a lasting memorial to their celebrated townsman.

Torricelli was born in 1608, and died in 1647. In the introduction to vol. i., Signor Loria has given the few particulars about his life which it has been possible to gather. In 1627 Torricelli went to Rome to study under Benedetto Castelli, a disciple of Galileo, who in the previous year had been appointed professor of mathematics there. He seems to have remained at Rome until October, 1641, when Galileo, who had heard from Castelli of the valuable work in dynamics done by his pupil, invited him to Arcetri. Torricelli gladly accepted the invitation, but was only for a few months able to benefit by the instruction thus offered, as Galileo died on January 6, 1642. Soon after, Torricelli was appointed to the post of mathematician to the Grand Duke of Tuscany held by Galileo, and spent the few remaining years of his life at Florence until his death on October 25, 1647. The subsequent fate of his unpublished papers and letters is told in the introduction; they had a narrow escape from total destruction in 1733, when they were sold as waste paper to a pork butcher. Fortunately, the first customer to whom one of the papers was handed, wrapped round a sausage, was Nelli, the biographer of Galileo, who to his horror recognised the handwriting of the great man, and at once secured the whole pile of papers.

It was the study of Galileo's "*Discorsi e dimostrazioni matematiche intorno a due nuove scienze*" which led Torricelli to make further investigations in dynamics and hydrodynamics. His principal results appeared in two books, "*De motu gravium naturaliter descendendum*" and "*De*

motu projectorum," which appeared in a volume of tracts, "*Opera geometrica*," published in 1644. It is the second of these which contains his experiments on the flow of fluids from vessels through a small orifice. These experiments had been commenced by Castelli, whose erroneous result, that the velocity of outflow was proportional to the depth from the surface, was corrected by Torricelli. He showed that the quantity of water flowing from a hole in the horizontal bottom of a vessel in equal times was proportional to the series of odd numbers, if the quantity flowing out in the last unit of time was put equal to one. A particle from the surface flows out with a velocity equal to that which it would have acquired by falling from its original height over the opening. Therefore the outflowing velocity is proportional to the square root of the height. From this it followed that the figure of a jet issuing from a small hole in the side of a vessel is a parabola. Among Torricelli's discoveries is also the mechanical principle that if two or more bodies are so connected that their motion will neither make their centre of gravity rise nor fall: they are in equilibrium.

The fame of Torricelli rests, however, mainly on his discovery of air-pressure. He knew from Galileo that water would not rise in a tube closed at the top more than 33 ft., which was supposed to indicate that Nature's dislike to empty space (*horror vacui*) had a limit. Torricelli thought that this was nonsense and that it would be interesting to experiment with a heavier fluid. He anticipated that mercury would rise only to one-thirteenth of the height to which water would rise. At his instigation Viviani made the experiment in 1643, and found that the column of mercury in a tube closed at one end and inverted in a vessel containing mercury sank to about 30 in. and remained there. Torricelli found, however, by repeated measures that the height of the column of mercury was always changing, and he rightly interpreted this as indicating changes in the pressure exercised by the air on the open surface of the mercury. In a letter to his friend Ricci of June 11, 1644 (vol. iii., p. 186), he says that he has made these experiments, not to produce a vacuum, but chiefly to make an instrument for measuring changes in the density of the air. He explains that we live at the bottom of an ocean of air, the weight of which at the surface of the earth is about equal to one-four-hundredth of the weight of an equal volume of water. During the remaining three years of his life Torricelli does not seem to have pursued these researches further, and the new doctrine was not universally accepted until Pascal in 1648 had proved the connection of barometric height with the height of the observer above the

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surface of the earth, and Guericke soon after had proved by experiments the enormous power of the pressure of the air.

Not a few of the mathematical papers published in the first (double) volume have never been printed before. They deal with conic sections, spirals (Torricelli discovered the logarithmic spiral), maxima and minima, etc. They make us feel that if a longer span of life had been granted him he would have taken his place among those mathematicians who paved the way for the advent of the differential calculus. The quadrature of the cycloid was one of the subjects treated in the "Opera geometrica." It is well known that Roberval charged Torricelli with having stolen his results on this subject, as well as Fermat's method of maxima and minima, and that Pascal was weak enough to publish this accusation in 1658, adding the assertion that Torricelli had confessed the robbery. This outrageous charge was soon after proved by Carlo Dati and Wallis to be utterly groundless, and it only showed that Roberval was not very particular as to the truth of any statement he made. There is no reason whatever to doubt that Torricelli found his results independently.

This new edition is in every way satisfactory, but we could have wished that the pages of the originals had been given in the margin. This is too often neglected by editors of a man's collected works, and the omission makes it very difficult to look up quotations from the original editions.

J. L. E. D.

PROBLEMS OF THE FRUIT-GROWER.

Science and Fruit-Growing: Being an Account of the Results obtained at the Woburn Experimental Fruit Farm since its Foundation in 1894. By the Duke of Bedford and Spencer Pickering. Pp. xxii+351. (London: Macmillan and Co., Ltd., 1919.) Price 12s. 6d. net.

THE appearance of this volume will be welcomed by all interested in scientific pomology, and the practical fruit-grower should find it indispensable as a work of reference dealing with many of the problems with which in some form or other he is constantly faced. In neither case will the contents be unfamiliar, since the investigations at Woburn have been closely followed throughout their course, and the results have been published at intervals in a series of reports. Some of the latter, however, have been long out of print, and for this and other obvious reasons the publication of a connected and comprehensive account of the many-sided work con-

ducted at Woburn since its foundation will be appreciated.

The preface quotes at length an article which appeared in *NATURE* of September 19, 1895, dealing with the genesis of the station, which was due entirely to the public-spirited enterprise of the Duke of Bedford, who furnished the necessary financial aid, and of Mr. Spencer Pickering, who has now for a quarter of a century devoted himself to the elucidation of some of the problems of the fruit-grower, and has laboured single-handed and under the additional handicap, in recent years, of ill-health. Under these conditions the volume of achievement has been remarkable; and although the authors recognise the limitation of aim necessitated by force of circumstances and plead for leniency of criticism, they may be assured that, notwithstanding the controversial character of much of their work and the storms of adverse opinion aroused from time to time, the world of horticulture recognises the great debt which it owes to them both for the value of their researches and for the stimulus given to scientific investigation in horticulture in this country.

It is impossible within the limits of a short review to include adequate notice of all the subjects of horticultural importance considered in this volume. Their range is extremely wide, successive chapters dealing with investigations on soil preparation for planting, methods of planting, pruning, manures, spring frost damage and its prevention, the fruiting of trees in successive seasons, the flowering of apple trees, insecticides and fungicides, insect and fungoid pests, soil sterilisation, the effect of grass on trees, the toxic action of one crop on another, the behaviour of plants in masses, and flocculation in soils. Since, however, opportunity for individual treatment has already been provided on the occasions of the appearance of the separate reports previously referred to, attention here may be confined to a few of the more general issues.

Except in the direction of chemistry, the goal aimed at was the investigation of those cultural problems in which much work could be done without the assistance of specialists in the respective branches of science concerned, since the station was not equipped for a more varied programme. The field of work which it was possible to cover within those limits was, however, remarkably wide, as the list of subjects just enumerated indicates. How far towards the solution of such cultural problems progress can be made under these conditions depends obviously on the nature of the individual problem; but, without in any way detracting from the value of the Woburn work, its main result has been to emphasise the need for